REMARKS

Claim Rejections - 35 U.S.C. § 103

The Examiner has rejected claims 16, 17, 19-22, 24, 27, 28, and 30 under 35 U.S.C. 103(a) as being unpatentable over Mertol (US 6,008,536) and further in view of Moeller (DE 19751463).

The Examiner has rejected claims 16, 17, 19-22, 24-28, and 30 under 35 U.S.C. 103(a) as being unpatentable over Smith (US 2001/0052652) and further in view of Miyao (JP4-364764) and Moeller.

The Examiner has rejected claims 16-22 and 24-30 under 35 U.S.C. 103(a) as being unpatentable over Smith and further in view of Jiang (US 6,812,064).

Response to 35 U.S.C. § 103 rejections

With respect to the rejection of claims 16, 17, 19-22, 24, 27, 28, and 30 under 35 U.S.C. 103(a) as being unpatentable over Mertol and further in view of Moeller, applicant submits that the present claims are patentable in view of Mertol and Moeller since these references all fail to disclose at least an element of the present claims, namely a thermal interface material comprising an electroactive polymer covalently bonded to a heat dissipating device and/or the heat generating device.

The present claims disclose an apparatus comprising a heat generating device, a heat dissipating device and a thermal interface material disposed between the heat generating and heat dissipating devices. Features of the present claims include a thermal interface material comprising an electroactive polymer bonded to the heat generating device and/or the heat dissipating device; and covalent bonds of

the thermal interface material to the heat generating device and/or the heat dissipating device.

1. Applicant submits that Mertol and Moeller all are silent with respect to a thermal interface material comprising an electroactive polymer. Examples of electroactive polymers include hybrid polymers having electroactive end groups, such as NH_n^+ or COO^-. The electroactive polymers can be deposited by electrodeposition, and resulted in physical bonding superior to traditional methods of adhesion, which may also reduce contact thermal resistance (paragraph [0022]).

Mertol discloses a thermal interface layer 36 disposed between an integrated circuit 12 and a heat spreader 16 with the thermal interface layer comprising conductive epoxy compounds, thermal grease, thermal wax, or thermal interface tape. Moeller is silent with respect to thermal interface layer, and discloses a hardener for improving adhesion between a metal and a resin. The hardener contains a hydrocarbon residue and has a first functional group reactive with the resin and a second functional group forming covalent or coordinate bond with the metal. The hydrocarbon residue is an aromatic or alicyclic hydrocarbon, preferably a substituted phenyl. The first functional group is a N,N-dialkyl urea residue. The second functional group is a phosphoric acid group, a silyl residue, a 5-hydroxy-1,4-naptho or a 9,10-anthraquinone group. Thus applicant submits that both Mertol and Moeller fail to disclose a thermal interface material comprising an electroactive polymer.

2. In addition, applicant submits that Mertol and Moeller all are silent with respect to a covalent bonding of a thermal interface material with either the heat generating or the heat dissipating device. Mertol discloses an integrated circuit 12, a thermal interface layer 36, and a heat spreader 16. Mertol is silent as to the presence of covalent bonds between the thermal interface layer and the heat spreader.

Moeller discloses a hardener (or an adhesion layer) to improve adhesion between a resin and a metal surface by covalent or coordinate bonds. Moeller is silent with respect to heat transfer processes and thermal interface materials. Applicant submits that the hardener disclosed by Moeller is an adhesion layer covalently (or coordinately) bonded to a metal surface to improve adhesion with a resin layer. Applicant further submits that the hardener layer is not a thermal interface material, which is disposed between a heat generating device and a heat dissipating device, and serves to provide an efficient thermal transfer process between these devices, at least since Moeller is silent to heat transfer, to heat transfer devices, and to heat transfer materials and properties. Thus the hardener layer of Moeller is not a thermal interface material, and Moeller fails to teach covalent bonding of a thermal interface material.

3. Further, applicant submits that it is not obvious to one of ordinary skill in the art to utilize the covalent bonding of an adhesion material with the purpose of improving adhesion of a coating layer (Moeller) to a bonding of a thermal interface material disposed between heat transfer devices with the purpose of improving heat conduction between these devices (Mertol). There is no one-to-one correspondence between adhesion bonding and thermal bonding. Typically, adhesion bonding provides structural support with high strength bonding between layers. For example, Mertol discloses an adhesion layer 40 to assist in attaching the heat spreader 16 to the substrate 14 (Mertol, Col. 8, lines 17-22). Moeller discloses that high strength adhesion bonding provides strong structural integrity, preventing water entrance and corrosion infiltration (Moeller, page 2, lines 24-28).

In contrast, thermal bonding provides low thermal contact resistance without regard to structural integrity. For example, Mertol discloses "bond line thickness" of the thermal interface material to reduce thermal resistance between chip 12 and heat spreader 16 (Mertol, Col. 8, lines 13-16). Paste materials can be used for thermal

bonding, such as thermal grease or thermal wax (Mertol, Col. 8, lines 28-30), which provide no structural rigidity at all.

Thus applicant submits that there is no suggestion or motivation to apply the covalent bonding of an adhesion process with the expressed purposed of improving high strength bonding to a thermal interface material for improving thermal contact resistance.

Applicant further submits that Mertol even provides a clear distinction between a thermal interface layer 36 and an adhesion layer 40, which essentially teaches away the interchangeability of these two processes.

As shown in Fig. 1, the interface layer 36 is disposed between a heat generated chip 12 and a heat dissipated heat spreader 16 to reduce the thermal resistance between the chip 12 and the heat spreader 16 (Col. 8, lines 13-16). By design, the thermal interface layer is positioned between a heat generating device (chip 12) and a heat dissipating device (heat spreader 16) for improving thermal conduction between these two devices. In contrast, the adhesion layer 40 is <u>not</u> disposed between a heat generating device and a heat dissipating device, but is disposed between the heat spreader 16 and the substrate 14 to <u>assist in attaching</u> the heat spreader 16 to the substrate 14 (Col. 8, lines 17-22). The adhesion layer is also subjected to a curing process to form strong bonds between the heat spreader 16 and the substrate 14 (Col. 8, lines 35-39).

Moeller discloses a resin coating process on a metal surface, employing a hardener layer having covalent bonds with the metal to improve the adhesion property between the resin and the metal. The hardener layer is also subjected to a curing process to improve the adhesion bonding between the resin and the metal surface. In view of Mertol's distinction between a thermal interface layer 36 and an adhesion layer 40, applicant submits that the hardener layer is disclosed as an adhesion layer providing structural support and not a thermal interface material

providing thermal conduction. Thus there is no motivation to apply the covalent bonding of an adhesion layer from Moeller to the thermal interface layer of Mertol.

Thus applicant submits that the present claims are patentable in view of Mertol and Moeller, since it is not obvious to combine Moeller's covalent bonding of an adhesion layer to improve high strength bonding to a thermal interface material of Mertol to improve thermal contact resistance.

4. Further, applicant submits that there is no motivation to combine the art of Mertol (which relates to semiconductor packaging with advanced heat transfer mechanism) and the art of Moeller (which relates to adhesion improvement of resin coating on a metallic surface). The arts of Mertol and Moeller are from different fields of endeavors, with Mertol disclosing advanced heat transfer mechanism for efficiently dissipation of heat from a chip, and Moeller disclosing a hardener for improving adhesion between a metal surface and a resin coating layer. Thus applicant submits that the combination of Mertol and Moeller is hindsight because express motivation to combine the references is lacking.

The examiner stated that Moeller discloses a method of improving adhesion between a metal surface and a heat curable resin by forming covalent bonds between the metal surface and the heat curable resin. Thus one of ordinary skill in the art would have found it obvious to use such a technique in the (heat transfer) method of Mertol since it provides improved adhesion between a metal surface and a heat curable resin. Applicant submits that the present claims disclose covalent bonds between a thermal interface material and a heat generating and/or heat dissipating device to improve thermal conduction from the heat generating to the heat dissipating devices. Since Moeller discloses covalent bonds to improve adhesion between the resin and the metal, and Moeller is silent with respect to a heat transfer process, applicant submits that it is not obvious to use an adhesion improving process of Moeller to improve heat conduction of Mertol. In addition,

applicant submits that Mertol and Moeller are from different field of endeavors, and thus motivation to combine these two references is lacking.

In sum, applicant submits that the present claims are patentable in view of Mertol and Moeller since these references all fail to disclose at least an element of the present claims, namely a thermal interface material comprising an electroactive polymer covalently bonded to a heat dissipating device and/or the heat generating device. In addition, applicant submits that motivation to combine these two references is lacking since these two references are from two different and distinct fields of endeavors.

Other claims are dependent claims, thus should be allowable, at least for the reason stated above with respect to the independent claims.

With respect to the rejection of claims 16, 17, 19-22, 24, 27, 28, and 30 under 35 U.S.C. 103(a) as being unpatentable over Smith and further in view of Miyao and Moeller, applicant submits that the present claims are patentable in view of Smith, Miyao and Moeller since these references all fail to disclose at least an element of the present claims, namely a thermal interface material comprising an electroactive polymer covalently bonded to a heat dissipating device and/or the heat generating device.

Smith, Miyao, and Moeller are all silent with respect to a thermal interface material comprising an electroactive polymer. Also, Smith and Miyao are silent with respect to a covalent bonding of the thermal interface material with either the heat generating or the heat dissipating device. And as discussed above, Moeller fails to disclose a covalent bonding of the thermal interface material with either the heat generating or the heat dissipating device.

In addition, as discussed above, there is no one-to-one correspondence between adhesion bonding and thermal bonding, thus it is not obvious to apply the

covalent bonding of an adhesion process with the expressed purposed of improving high strength bonding to a thermal interface material for improving thermal contact resistance.

Further, applicant submits that there is no motivation to combine the art of Smith and Miyao (which relates to semiconductor packaging with advanced heat transfer mechanism) and the art of Moeller (which relates to adhesion improvement of resin coating on a metallic surface). The arts of Smith/Miyao and Moeller are from different fields of endeavors, with Smith/Miyao disclosing advanced heat transfer mechanism for efficiently dissipation of heat from a chip, and Moeller disclosing a hardener for improving adhesion between a metal surface and a resin coating layer. Thus applicant submits that the combination of Smith/Miyao and Moeller is hindsight because express motivation to combine the references is lacking.

The examiner stated that Moeller discloses a method of improving adhesion between a metal surface and a heat curable resin by forming covalent bonds between the metal surface and the heat curable resin. Thus one of ordinary skill in the art would have found it obvious to use such a technique in the (heat transfer) method of Smith since it provides improved adhesion between a metal surface and a heat curable resin. Applicant submits that the present claims disclose covalent bonds between a thermal interface material and a heat generating and/or heat dissipating device to improve thermal conduction from the heat generating to the heat dissipating devices. Since Moeller discloses covalent bonds to improve adhesion between the resin and the metal, and Moeller is silent with respect to a heat transfer process, applicant submits that it is not obvious to use an adhesion improving process of Moeller to improve heat conduction of Smith. In addition, applicant submits that Smith and Moeller are from different field of endeavors, and thus motivation to combine these two references is lacking.

Other claims are dependent claims, thus should be allowable, at least for the reason stated above with respect to the independent claims.

With respect to the rejection of claims 16-22 and 24-30 under 35 U.S.C. 103(a) as being unpatentable over Smith and further in view of Jiang, applicant submits that the present claims are patentable in view of Smith and Jiang since these references all fail to disclose at least an element of the present claims, namely a thermal interface material comprising an electroactive polymer covalently bonded to a heat dissipating device and/or the heat generating device.

Smith and Jiang are all silent with respect to a thermal interface material comprising an electroactive polymer. Also, Smith is silent with respect to a covalent bonding of the thermal interface material with either the heat generating or the heat dissipating device.

Applicant submits that Jiang also fails to disclose a covalent bonding of the thermal interface material with either the heat generating or the heat dissipating device. Jiang is silent with respect to covalent bonding, and discloses that a hydrophobic, hydrogen-terminated silicon layer does not bond well to an adhesive paste (Col. 4, lines 21-23), and that silicon dioxide surface layer is a superior chemical layer for adhering to an adhesive paste (Col. 4, lines 36-38).

The examiner stated that applicant recognizes that oxidizing the silicon substrate forms covalent bonds between the silicon substrate and the epoxy interface material (Paragraph [0024]).

> *For one embodiment, a surface of the heat dissipating device and/or the IC may be chemically treated to generate a functional group which may react with the TIM to form covalent bonds. For example, a silicon surface of the IC may be oxidized by an oxidizing agent such as $KMnO_4$, to generate COOH or OH which may react with a polymer-based TIM, such as an epoxy resin. As*

another example, a surface of the heat dissipating device may be treated to form aluminum oxide (Al_2O_3), which may react with a COOH terminated TIM.

Applicant respectfully submits that forming a covalent bond requires a preparation of both surfaces, such as an aluminum oxide surface of the heat dissipating device and a COOH terminated surface of a TIM; or a silicon oxide surface with COOH or OH to react with a polymer-based TIM. Applicant submits that simply oxidizing a silicon surface is not adequate to form covalent bond with an epoxy material.

In addition, Jiang discloses an adhesion bonding process to improve bonding to a substrate. Jiang is silent with respect to heat transfer processes and thermal interface materials. As discussed above, there is no one-to-one correspondence between adhesion bonding and thermal bonding, thus applicant submits that it is not obvious to apply the bonding of an adhesion process with the expressed purposed of improving high strength bonding to a thermal interface material for improving thermal contact resistance.

Further, applicant submits that there is no motivation to combine the art of Smith (which relates to semiconductor packaging with advanced heat transfer mechanism) and the art of Jiang (which relates to adhesion improvement of an adhesive paste to a semiconductor die). The arts of Smith and Jiang are from different fields of endeavors, with Smith disclosing advanced heat transfer mechanism for efficiently dissipation of heat from a chip, and Jiang disclosing an oxidation process for improving adhesion of an adhesive paste to a silicon die. Thus applicant submits that the combination of Smith and Jiang is hindsight because express motivation to combine the references is lacking.

As such, Applicant respectfully requests the removal of the 35 U.S.C. § 103 rejections of claims 16-22, and 24-30 and seeks an early allowance of these claims.

Pursuant to 37 C.F.R. § 1.136(a)(3), applicant(s) hereby request and authorize the U.S. Patent and Trademark Office to (1) treat any concurrent or future reply that requires a petition for extension of time as incorporating a petition for extension of time for the appropriate length of time and (2) charge all required fees, including extension of time fees and fees under 37 C.F.R. §§ 1.16 and 1.17, to Deposit Account No. 02-2666.

Respectfully submitted,

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